R-862 (Revised)

Sweetclover

Production and Management

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Biennial sweetclover is a legume introduced into the United States from Europe and Asia in the early 1700s. It first was considered a weed because of its widespread occurrence along roadsides and in waste areas. During the early years of this century, it was discovered to be a valuable forage for hay, pasture and silage; soil improvement; and a pollen source for honey bees.

Adaptation

Biennial sweetclover is a winter-hardy, drought-tolerant legume that is adapted to a wide range of soils. It can be found growing on rocky, nearly barren slopes; road rights of way; rangeland areas; coal mine spoils; saline-alkali soils of moderate salinity; and low-fertility soils. Sweetclover is invading native range areas in southwestern North Dakota and is widespread on South Dakota range. Sweetclover grows best on fertile, well-drained, calcareous soils. It cannot tolerate flooding once growth begins in the spring. Prior to starting growth in early spring, it can withstand flooding for about 10 days without serious stand loss.

Varieties and Strains

Biennial sweetclover includes both the yellow-flowered (*Melilotus officinalis* Lam.) and white-flowered (*M. alba* Medik) varieties and strains. The yellow-flowered sweetclover is shorter growing, more widely branched, finer stemmed, more drought tolerant, easier to establish and better adapted to the drier regions of North Dakota than white-flowered sweetclover.

A number of sweetclover varieties have been released throughout the United States and Canada. Distinct varieties are not readily available today due to low producer demand. However, some low-coumarin varieties are available from Canada. The common yellow-flowered strain is the most widely grown throughout North Dakota. Many yellow-flowered strains grown today trace back to the variety Madrid, but the seed identity has been lost. A brief description of varieties or strains available for planting is provided in Table 1.

Varieties of sweetclover also are classified by the coumarin content. Coumarin is an aromatic compound that affects the palatability of sweetclover forage until animals adapt to the bitter taste. Mold in sweetclover forage converts coumarin to dicoumarol, a blood anti-coagulant. Animals fed moldy sweetclover hay may suffer from the sweetclover bleeding disease. Most cultivars are high in coumarin content, usually 2 percent to 2.5 percent. Low-coumarin varieties such as Norgold and Polara have been selected for very low levels of coumarin. Low-coumarin varieties generally are lower yielding, but they should be used to reduce the risk of the bleeding disease.

Forage Yield

Forage yields of all available sweetclover varieties or strains have not been obtained during the same time period at the North Dakota Agricultural Experiment Station's Main Station in Fargo and Research Extension Centers elsewhere in the state. Therefore, yield data based on limited test years may not reflect valid variety comparisons because of variable rainfall during test periods. In general, the forage yield in western North Dakota can be expected to be 50 percent or less of that obtained at Fargo. Forage yield data and number of station test years for several locations are provided in Table 2.

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Table 1. Description of available sweetclover varieties and strains.

Variety or strain	Maturity rating	Remarks
Yellow-blossom		
Common yellow	Very early	Composite of local strains. Seed production is good.
Goldtop	Medium	Released in 1956 by Wisconsin Agricultural Experiment Station. Excellent seedling vigor. Two weeks later in maturity than Madrid.
Madrid	Early	Introduced in 1910 by the USDA Division of Plant Introduction from Madrid, Spain. Has good seedling vigor and is quite resistant to fall frost. Seed production is heavy.
Norgold	Early	LOW-COUMARIN variety. Released in 1981 by Agriculture Canada. Yields slightly less forage and possesses lower spring vigor than other yellow-flowered strains. Use certified seed to assure low-coumarin content forage for hay.
Yukon	Early	Released in 1970 by Agriculture Canada. A selection from the variety Madrid. Matures one to three days earlier than Madrid but is more winter-hardy and more tolerant of fall frosts and mowing during year of seeding. High seed yield.
White-blossom		
Common white	Medium	Composite of local strains. Seed production good.
Evergreen	Late	Released in 1935 by the Ohio Agricultural Experiment Station. Maturity is 14 to 21 days later than common white. Blooms during a long period. High seed yield is difficult to obtain.
Polara	Medium	LOW-COUMARIN variety. Released by Agriculture Canada in 1970. Use certified seed to assure low-coumarin content forage for hay.

Table 2. Forage yield (tons/acre of 12 percent moisture forage) of sweetclover varieties or strains at various North Dakota locations.

Variety or strain	Fargo		Fargo		Edgeley		Dickinson		Streeter	
	No. yrs.	Ave. yield	No. yrs.	Ave. yield	No. yrs.	Ave. yield	No. yrs.	Ave. yield	No. yrs.	Ave. yield
		Tons/ acre		Tons/ acre		Tons/ acre		Tons/ acre		Tons/ acre
Yellow-blossom										
Common yellow			15	2.7	2	2.1	6	1.4	1	2.1
Goldtop	2	2.4	11	4.2	2	2.4	6	1.7	—	—
Madrid	2	2.3	15	2.6	2	2.6	6	1.5	1	2.3
Norgold	2	1.8	—	—	—	—	—	—	1	2.1
Yukon	2	1.8	—	—	—	—	—	—	1	1.7
White-blossom										
Common white	—	—	15	2.5	2	2.7	6	1.6	—	—
Evergreen	—	—	10	3.3	2	2.9	—	—	—	—
Polara	—	—	—	—	—	—	5	1.9	1	1.7
Denta	2	1.8								

Seedbed Preparation

A firm seedbed free of crop residue and weeds is essential to obtain good stands of sweetclover. A firm seedbed can maintain high soil moisture levels near the soil surface and provide favorable conditions to permit uniform shallow seeding.

Date of Planting

Spring is the best time to plant sweetclover. Early season moisture conditions are more favorable for rapid seed germination and seedling establishment.

Late summer and fall seedings are not recommended since young sweetclover seedlings usually will not develop enough to survive the winter. Sweetclover grows slowly for the first 60 days after planting. The sweetclover plant must develop an extensive root system and store high levels of plant food in the roots during the fall growth period. These stored food reserves are essential in overwintering the sweetclover plant and to assure a vigorous, productive stand the following year.

Rate of Planting

A high proportion of newly harvested sweetclover seed is "hard." The impermeable seed coat does not permit uptake of water for germination. Hard seed usually is live seed. It can lie in the soil for more than 20 years, germinate and produce healthy seedlings. Newly harvested sweetclover seed may contain 50 percent or more hard seed. The seed trade reduces hard seed content in sweetclover through a process called scarification. This process scars or scratches the seed coat, providing an entry point for moisture necessary for germination.

The seeding rate of sweetclover varies depending on the percentage of hard seed, actual seed, germination, seedbed preparation, seeding method and intended use. To determine the actual seeding rate of sweetclover based on seed quality, do not count more than 25 percent hard seed when computing the total potential germination percentage. Table 3 provides suggested seeding rates for sweetclover by seeding method.

Table 3. Suggested sweetclover seeding rates.

	Seedbed condition	
Seeding method	**Good**	**Average**
Drilled	4	6
Broadcast, harrowed	5	8
Broadcast	6	10

Depth of Planting

Sweetclover is a small-seeded legume and requires uniform, shallow seeding into a firm seedbed for successful seedling emergence and adequate stand establishment. The recommended planting depth is ¼ to ½ inch deep on medium- to heavy-textured soils and ½ to 1 inch on sandy soils. Seeding too deep is one of the most common causes of poor stand establishment. Studies have shown a sharp reduction in seedling emergence (Table 4) with seeding depths greater than 1 inch.

Table 4. Effect of seeding depth on sweetclover seeding emergence.

Planting depth (inches)	% emergence	No. days for emergence
0.5	98	4
1.0	88	5
1.5	46	6
2.0	20	7
2.5	2	9
3.0	0	–

Inoculation

Sweetclover, like other legumes, can capture and fix some of its own nitrogen. Legumes require a special kind of nitrogen-fixing bacteria to manufacture nitrogen from the air. The kind of bacteria required depends on the kind of legume being planted. Sweetclover and alfalfa require the same bacteria to induce formation of effective nodules on the roots.

Sweetclover seed always should be inoculated before planting. Use the proper strain of nitrogen-fixing bacteria. This will help ensure the formation of effective nodules or "nitrogen factories" to fix atmospheric nitrogen into a form the plant can use. The seed serves only as a carrier to place the proper bacterial strain in the soil to facilitate nodule formation on root hairs.

Always use fresh cultures of bacteria for seed inoculation or use pre-inoculated seed. Store inoculum and/or pre-inoculated seed in a cool place away from sunlight. High temperatures will cause bacteria cultures to lose their effectiveness in a short time.

Companion Crops

Companion crops often are used with new seedings of sweetclover for economic reasons. Use an early maturing companion crop if it is to be harvested as grain or remove late-maturing companion crops as hay or silage. Companion crop management will be most important in low-rainfall areas and on coarse-textured soils throughout the

state. When removing the companion crop, leave a minimum 6-inch stubble height to encourage adequate fall sweetclover growth and a buildup of root reserve to maintain a vigorous stand.

Seeding Methods

A press drill with a grass seed attachment equipped with a seed agitator is satisfactory for seeding sweetclover, provided a firm seedbed is prepared. Sweetclover seed ***should not*** go down the same spout as the companion crop. Place the seed spouts from the small-seeded grass and legume box to drop the seed behind the double-disc opener and in front of the press wheels. The press wheels will tend to cover and firm the soil over the seed. Use a lightweight spring tooth harrow following this method of seeding to incorporate seed into the soil, but use caution. Harrowing soft seedbeds could cover the seed too deep, so don't use heavy harrows.

Using press drills without a legume box requires that seed be mixed with small grain for effective seeding. If the seedbed is not firm, pack by harrowing and/or running the press drill over the field prior to seeding. Another seeding approach is to seed a portion of the small-grain companion crop first, then mix the sweetclover seed with the remaining grain and drill in the opposite direction.

Broadcast seedings often are successful in higher rainfall areas if planted in early spring, and surface soil moisture is adequate for seven to 10 days for germination and seedling root growth.

No-till Seedings

Excellent stands of sweetclover are possible with early spring no-till seeding into a clean small-grain stubble. However, no-till seedings are not recommended since no herbicides are cleared for application to sweetclover for weed control.

Fertilization

Sweetclover will manufacture its own nitrogen from the air if inoculated properly. Therefore, the primary fertilizer nutrients required are phosphorus and potassium. Sweetclover will remove about 12 pounds of P_20_5 and 50 pounds of K_20 from the soil per ton of forage produced. The fertilizer amount required will depend on the ability of the soil to supply these nutrients. A soil test for phosphorus and potassium will be the best guide to fertilizer requirements. Table 5 shows the recommended annual broadcast application rates of phosphorus (P_20_5) and potassium (K_20) based on soil test levels and expected yield goal.

Weed Control

No herbicides are labeled or approved for application on either seedling or established sweetclover. When a cereal grain is underseeded with sweetclover and weed pressure requires control measures, follow the herbicide recommendation for the cereal grain.

First-year Growth and Management

Once sweetclover has germinated, the stems and leaves develop slowly and the root system develops rapidly for a period of six to eight weeks. This is followed by a more rapid development of stems and leaves. Top growth reaches maximum development by late summer. The size of the taproot system continues to increase during late summer and fall. Crown buds, formed about 1 inch below the soil surface, become large and conspicuous as the root increases in size (Figure1). Growth the second year will be initiated from crown buds developed during the fall of the seeding year.

Carbohydrate storage (starches and sugars) increases sharply during the late summer and fall of the seeding year. Storage of food reserves in the root and crown depends upon an adequate and vigorously growing

Table 5. Annual broadcast application rates of phosphate and potash for sweetclover.

		Soil test phosphorus, ppm					Soil test potassium, ppm				
Yield goal	Bray-I Olsen	VL 0-5 0.3	L 6-10 4.7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/A		- - - - - - - - - - lb P_20_5/acre - - - - - - - - - -					- - - - - - - - - - lb K_20/acre - - - - - - - - - -				
2		35	25	15	10	0	105	75	45	10	0
4		65	50	30	10	0	195	140	80	25	0
5		85	60	40	15	0	245	170	100	30	0
6		100	70	45	15	0	295	205	120	35	0

Bray-I P recommendation - (18.57-0.93 STP) YG
Olsen P recommendation - (18.57-1.16 STP) YG
Potassium recommendation - (55.71-0.38 STK) YG

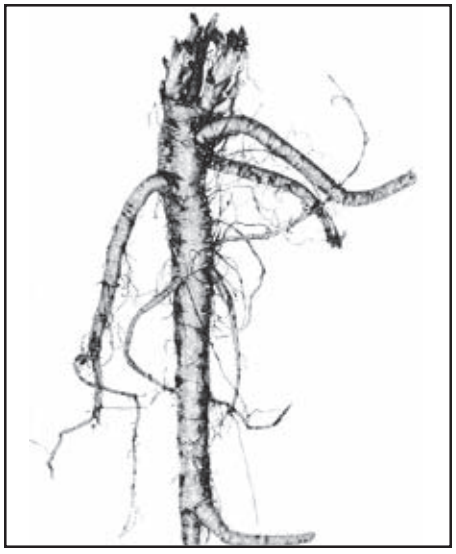

Figure 1. Fleshy root of first-year sweetclover plant. Note crown buds or rhizomes from which second year's growth begins.

food factory, the green leaves and stems. Any practice such as close mowing or grazing during the fall of the seeding year will reduce the plant's ability to develop a large root system and store adequate food reserves. Improper fall management will result in possible loss of plants through winter-kill, slow spring growth and less forage production the year after establishment.

The least injurious method for using some of the forage during the establishment year is to pasture at a moderate rate near the end of the food storage period late in September or following a killing frost. Leave a 5- to 6-inch standing stubble to catch snow for winter protection. If harvested for hay in the seeding year, harvest before Aug. 10 to 15 to allow adequate time for regrowth to replenish root reserves and leave a 6-inch stubble height to save active auxiliary buds.

Sweetclover seldom flowers during the year of establishment. Day length triggers the enlargement of the root in the fall and development of short, stout rhizomes from buds on the crown.

Second-year Growth and Management

The second year's growth of sweetclover develops from crown buds or rhizomes formed the fall of the seeding year. The nutrients stored in the roots the previous fall are used during the first few weeks of growth and are not replaced until summer. Second-year growth consists almost entirely of tops. If part of the forage is removed early in the growing season, new growth must come from buds on the stem since all crown buds initiate growth in the spring.

In areas receiving enough rainfall to produce a second crop of hay, the sweetclover plant must be cut high enough to permit regrowth from live buds on the stubble. The heavier the sweetclover stand, the shorter it is cut and the later in maturity it is cut, the greater the chance that mowing will kill the plant. If a second crop is desired, cut the crop 6 to 12 inches tall at the early bud growth stage. The later the cutting is made, the higher the stubble required to obtain regrowth forage.

Some producers leave 12-inch stubble in an attempt to improve the forage quality. But harvesting at an early growth stage (early to late bud) does more to improve forage quality than leaving additional stubble.

Pasturing Sweetclover

Sweetclover is bitter tasting to livestock due to the presence of coumarin. When livestock chew sweetclover, free coumarin is released, producing an undesirable taste that reduces its palatability. When grazing sweetclover pasture, don't make other forage available for grazing. Livestock graze sweetclover forage sparingly when first turned onto pasture because of the bitter taste, but the animals soon become accustomed to the taste and graze without difficulty.

Bloat may be a problem when grazing immature sweetclover. Bloat occurs less frequently when grazing sweetclover, compared with alfalfa. Take certain precautions because the danger of bloat always is present. Precautionary measures to reduce the potential bloat hazard include: 1) Place livestock on pasture with a fill of dry feed, 2) provide dry feed for animals at all times while on pasture not used previously, and 3) provide an adequate supply of water and salt.

Sweetclover should be considered only as a backup or temporary pasture for livestock. In areas of higher rainfall, annual stand establishment will be more dependable than in low-rainfall areas, permitting the use of sweetclover in a regular pasture program. Successful stand establishment is not always possible, especially in western North Dakota.

Grazing may begin on second-year sweetclover when new growth is 6 to 8 inches tall. During May and June, when the plant is making rapid growth, the stocking rate should be heavy enough to prevent the plant from becoming too coarse and unpalatable. Maintain a minimum stubble height of about 6 inches to promote regrowth forage. If the plants become coarse and stemmy, a stubble height of 10 to 12 inches may be required for regrowth.

Sweetclover should provide grazing for a period of 60 to 90 days during May, June and July. The stocking rate will be similar to other well-managed cool-season pastures in the area.

Two-year-old steers grazed sweetclover pasture in early trials at the Northern Great Plains Research Center at Mandan. The carrying capacity of the pasture varied

depending upon the density of stand established. Steer performance data for two trial years are given in Table 6.

Steers grazed season long performed well through the month of August. During the second year, additional steers were placed on the pasture at midseason because excess forage was available. The steers placed on pasture in midseason did not gain as well as the full-season grazed steers.

Controlling Sweetclover on Range

Nothing will control sweetclover totally once established on native range. Broadleaf herbicides, such as 2,4-D, will kill the present year's growth, but a new stand establishes from dormant seed in the soil for up to 20 years. However, concentrated grazing during August, September and October can reduce sweetclover plant density. Concentrated grazing reduces root reserves, which increases winter kill. Grazing will not eliminate sweetclover, but it should help keep the stand at an acceptable level.

Hay or Silage Utilization

Sweetclover generally has not been favored for hay production due to the difficulty of curing the coarse stems. However, hay conditioning equipment now available speeds the curing process. If sweetclover is cut at the proper time and adequately cured, it is comparable to alfalfa in feed value. Sweetclover, especially high-coumarin varieties, should be baled drier than other grass and legume hay, preferably at 17 percent to 18 percent moisture or less for small, square bales and 13 percent to 14 percent for large bales because of the presence of coumarin in the forage. Sweetclover hay stored too wet will mold and may cause sweetclover bleeding disease when fed as the only roughage to livestock. Growing a certified seed of a low-coumarin variety, such as Norgold, can avoid problems associated with feeding moldy sweetclover hay.

ONLY GROWING CERTIFIED SEED CAN ELIMINATE THE PROBLEM OF SWEETCLOVER BLEEDING DISEASE. If sowing other than certified seed, contamination with high-coumarin varieties is highly probable. This increases the potential risk of sweetclover bleeding disease.

Harvest sweetclover for hay at the bud to 10 percent bloom growth stage for high-quality forage. Forage yield of Madrid sweetclover was similar when harvested at the bud to 10 percent bloom stage in a Fargo study (Table 7). Delaying harvest of the first crop until the late-bloom growth stage decreased forage yield. In addition, forage digestibility declined from about 71 percent at 10 percent bloom to 63 percent at the late-bloom growth stage. Protein content of the early harvested forage ranged from 21 percent to 22 percent.

Harvest sweetclover for silage at early flowering for optimum forage quality and near optimum yield. Late-bloom sweetclover will yield more forage and can be used best as a silage because the coarse, woody stem sections are more palatable after the ensiling process.

The moisture content of the forage as it goes into the silo is the key to making good-quality silage. It should average about 65 percent when stored in conventional upright silos, bunker silos or above-ground piles. Sweetclover stored as haylage or low-moisture silage should have a moisture content of 55 percent to 65 percent when stored in oxygen-limiting silos or conventional upright silos, bunker silos or above-ground piles. Regardless of the storage structure, cut at the proper growth stage, fill rapidly, chop fine to aid packing and cover to exclude outside air from entering the silage mass. Be sure to discard the moldy surface when feeding sweetclover silage since this layer can be very high in dicoumarol content.

Table 7. Total forage and digestible forage yield (tons/acre) of Madrid sweetclover harvested by growth stages at Fargo, N.D.

Growth stage	Tons D.M./acre			
	Cut 1	Cut 2	Total	Digestible
Midbud	2.0	0.9	2.9	2.1
10% bloom	2.3	0.7	3.0	2.0
Late bloom	2.1	—	2.1	1.3

Table 6. Performance of 2-year-old steers on sweetclover pasture, Mandan, N.D.

Trial year	Monthly gain/steer					Seasonal gain/steer			Acres per steer	Days grazed
	May	June	July	Aug.	Sept.	per head	per day	per acre		
	pounds									
1	28	69	62	—	—	159	2.65	79.5	2	60
2	49	77	84	87	22	286	2.38	143.0	2	120

Use caution when feeding sweetclover hay or silage as the major portion of the livestock ration, especially if high-coumarin varieties are grown. The coumarin in sweetclover is converted to dicoumarol, a toxic substance in moldy or spoiled hay or silage, and may cause "Sweetclover Bleeding Disease." Dicoumarol reduces the animal's blood clotting rate. Animals may bleed to death from slight wounds or internal hemorrhages. If animals are to be dehorned or castrated, do not feed sweetclover forage for at least three weeks prior to working cattle and at least 30 days prior to calving.

Seed Production

Shattering losses can be a severe problem when harvesting sweetclover for seed. The most suitable growth stage to hold shattering losses at a minimum is when 60 percent of the seed pods have turned brown or black. A study using the variety Evergreen indicates that highest seed yields are obtained if the crop is swathed when 30 percent to 60 percent of the seed pods turn brown or black. Harvesting at these maturity stages did not affect seed germination significantly. Seed yields and date of harvest at Fargo are shown in Table 8 for the years of 1965 and 1967 (the latest data available) for several varieties and strains.

Table 8. Average seed yields and date of harvest of sweetclover, Fargo, N.D.

Variety or strain	Seed yield lbs/acre	Harvest date
Goldtop	430	Aug. 22
Madrid	717	Aug. 11
Common yellow	658	Aug. 11
Denta	553	Sept. 16

The USDA Statistical Reporting Service provided sweetclover seed yield data for North Dakota from 1939 to 1970. The average sweetclover seed yield for the 32-year period was 177 pounds per acre. During the 1960 to 1970 period, the average seed yield was 245 pounds per acre. However, seed growers in the Dickinson area report seed yields as high as 600 pounds per acre with an estimated average yield of about 400 pounds.

Soil Improvement

A major benefit of sweetclover in the crop rotation is its ability to fix atmospheric nitrogen into a form that's useable to plants. In addition, its deep penetrating, widely branched root system improves soil drainage, aeration and the soil's general physical condition. Sweetclover plowed under as green manure the year following establishment adds considerable organic matter to the soil, improving soil tilth and the ease of tilling soils. Sweetclover often is grown on saline-seep contributing areas to use deep soil moisture, reducing the lateral flow of water that forms the seep area in crop-fallow rotations.

Table 9. Nitrate nitrogen in 36-inch depth soil and average wheat yields on sweetclover management plots. Fargo, N.D.

Management the previous season	lbs/acre No_3-N April 1955	lbs/acre No_3-N May 1956	lbs/acre No_3-N Ave.	Wheat yield 1919-1956 bus/acre
Regular fallow, no sweetclover	70	165	117	30.8
Sweetclover plowed early cropped to flax	41	72	56	23.2
Sweetclover plowed early fallowed	110	256	183	30.7
Sweetclover plowed at bud stage, fallowed	159	209	184	31.9
Sweetclover 1st crop hay, 2nd crop - plowed down at bud, fallow	110	189	149	29.3
Sweetclover 1st and 2nd hay crops, fall plowed	38	103	70	24.6
Sweetclover 1st hay crop 2nd seed crop fall plowed	35	63	49	23.1

Source: Unpublished data - NDSU Soils Department

The amount of nitrogen that legumes grown in the rotation add to the soil depends on how the crop is managed. Studies at Fargo (Table 9) show that sweetclover plowed down as green manure crop added greater amounts of total nitrate nitrogen than when top growth was removed for forage or a seed crop was harvested and then plowed.

Approximately 50 percent to 60 percent of the nitrogen contained in legume tops and roots is obtained from the atmosphere. The remaining nitrogen is obtained from the soil and does not represent a net gain in nitrogen.

The nitrate nitrogen data in Table 9 indicates that sweetclover can be plowed as green manure before the bud stage of plant growth and not affect the amount of nitrogen fixed. Sweetclover may be plowed under the year following seeding when the plants are 6 to 10 inches tall. If plowed too early, the crown buds may develop new shoots because stored food reserves in the root and crown still are high. Late plowing adds more organic matter to the soil, but the additional growth period tends to dry out the soil to deeper depths and decomposition of the plant material will be slower. A fallow period of at least six weeks following sweetclover plowdown as green manure or hay crop stubble is recommended to allow for soil moisture recharge.

Nitrogen availability to crops the year following sweetclover plowdown depends on the rate of decomposition of tops and roots. The additional nitrogen in the soil is not all available immediately and may increase the yield and protein content of crops for several years (Figure 2). In higher rainfall areas of North Dakota, the yields of wheat in rotation with sweetclover have been equal to or slightly higher than wheat-fallow rotations. Wheat yields have been somewhat lower following sweetclover, compared with wheat-fallow rotations in drier areas of the state.

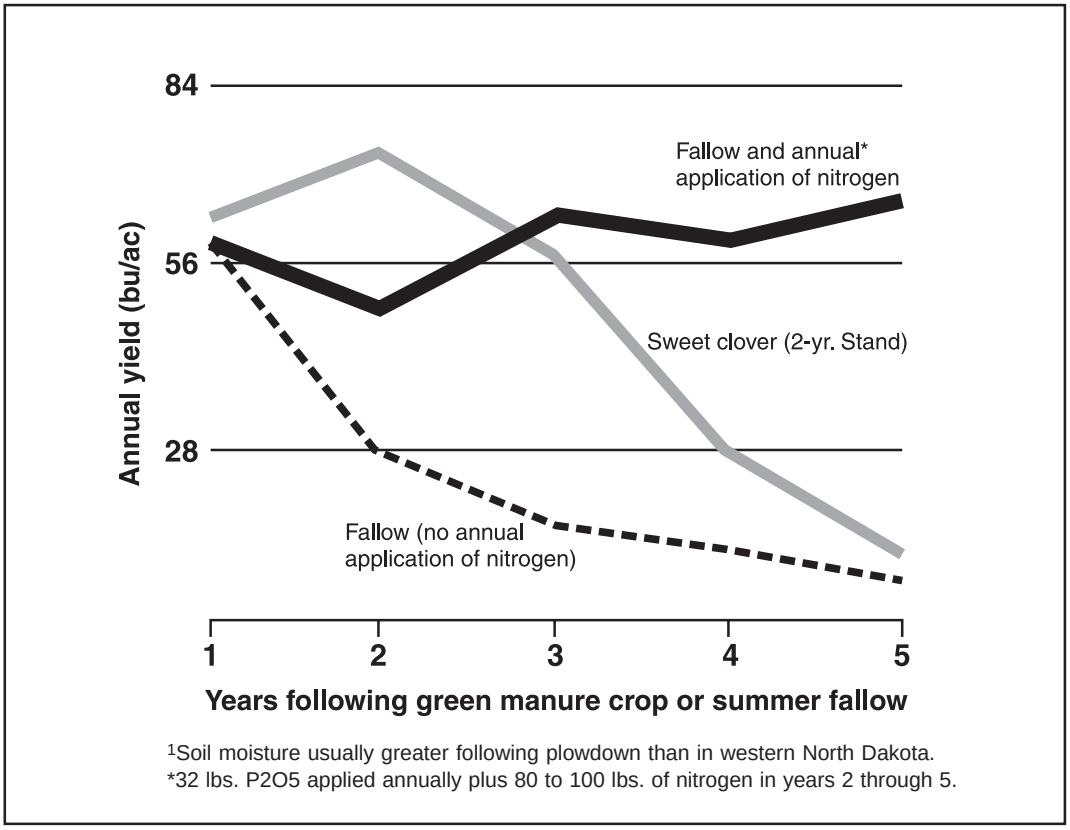

Figure 2. Annual yield of continuous barley following a sweetclover green manure crop and summer fallow. Brandon, Man., Canada.[1]

For more information on this and other topics, see: www.ag.ndsu.edu

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